ORIGINAL ARTICLE

Association of rear seat safety belt use with death in a traffic crash: a matched cohort study

Motao Zhu, Peter Cummings, Haitao Chu, Lawrence J Cook

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See end of article for authors' affiliations

Correspondence to: Dr M Zhu, Bureau of Injury Prevention, New York State Department of Health, 150 Broadway, 3rd Floor - West, Albany, NY 12204, USA; mxz04@health.state.ny.us

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Objective: To estimate the association of rear seat safety belt use with death in a traffic crash.
Design: Matched cohort study.
Setting: The US during 2000 through 2004.
Subjects: Drivers (10 427) and rear seat passengers (15 922) in passenger vehicles that crashed and had at least one driver or rear passenger death. Data from the Fatality Analysis Reporting System.
Main outcome measures: The adjusted relative risk (aRR) of death for a belted rear seat passenger compared with an otherwise similar unbelted rear passenger.
Results: Safety belt use was associated with a reduced risk of death for rear car occupants: outboard rear seat aRR 0.42 (95% CI 0.38 to 0.46), and center rear seat aRR 0.30 (95% CI 0.20 to 0.44). For rear occupants of light trucks, vans, and utility vehicles, the estimates were: outboard aRR 0.25 (95% CI 0.21 to 0.29), center aRR 0.34 (95% CI 0.24 to 0.48).
Conclusions: If the authors' estimates are causal, traffic crash mortality can be reduced for rear occupants by approximately 55–75% if they use safety belts.

Approximately 263 000 rear seat passengers riding in passenger cars or light trucks were injured during motor vehicle crashes in the US in 2003.[1] Although safety belts have been effective in reducing fatal and non-fatal injuries in motor vehicle crashes,[2] their usage is substantially lower among adult rear seat passengers than among front seat occupants. Nationwide, in 2004, the shoulder safety belt use prevalence was only 47% for rear seat occupants, compared to 80% for front seat occupants.[3]

Most studies of safety belts have focused on use among front seat occupants or rear seat child passengers. In a few studies of back seat restraint use by adults, estimates of reduction in the risk of death by safety belt use ranged from 18% to 73%.[4–6] Our objective was to estimate the association between safety belt use and death among adult rear seat occupants in recent crashes. We also wished to examine whether rear seat safety belt effectiveness varied by whether the vehicle was a car or a light truck (including vans and utility vehicles), by seat position (outboard, center), occupant age, and whether or not the vehicle rolled over.

METHODS

Study design

We applied a matched-set cohort design using data from vehicles where at least one individual experienced the study outcome, death.[7 8] This design is useful in traffic fatality studies because information is not routinely collected from vehicles in which all occupants survived. Since occupants of the same vehicle are naturally matched on crash and vehicle characteristics, this method removes potential confounding of crash and vehicle-related factors, such as vehicle speed and collision type.

Data source and study population

We analyzed vehicles from the Fatality Analysis Reporting System (FARS) that crashed during the years 2000 through 2004 in which there was at least one rear seat passenger aged 16 years or older in the vehicle, and the driver or at least one rear seat passenger aged 16 or older died from the crash. FARS is maintained by the National Highway Traffic Safety Administration (NHTSA) and contains data for all motor vehicle crashes that result in at least one fatality within 30 days of the crash.[9] Front seat passengers were not included in our analysis. We included passenger cars and light trucks with a second row of seats with model years from 1975 through 2005.

As this study was based upon publicly available data no ethics approval was needed.

Analysis variables

Safety belt use, our primary exposure variable, was treated as dichotomous (yes or no). If an occupant was coded as using a lap belt, shoulder belt, or lap and shoulder belt, we classified them as using a safety belt. Our primary outcome variable was death. The potential confounding variables for which we adjusted were: occupant's gender, occupant's age (16–19, 20–34, 35–64, 65 years or older), seating position (driver, outboard rear seat, center rear seat), and air bag presence (yes, no). Additional potential effect modifying variables that we considered were vehicle body type (passenger car or light truck), vehicle rollover status (yes, no), vehicle model year, and calendar year. The NHTSA's definition was applied to identify passenger vehicles, which includes passenger cars (convertible, coupe, hatchback, hardtop, sedan, station wagon, auto pickup, auto panel, other auto), light trucks (compact pickup, standard pickup, pickup with camper, convertible pickup, cab chassis based, truck based panel, other light conventional), vans (minivan, large van, step van), and utility vehicles (compact utility, large utility, utility station wagon).[9] We classified light trucks, vans, and utility vehicles as light trucks and refer to that group as light trucks throughout this paper.

Statistical analysis

To estimate the adjusted relative risk (aRR) of a fatality in a traffic crash for belted rear seat passengers or drivers compared with those unbelted we used the Cox proportional hazards

Abbreviations: FARS, Fatality Analysis Reporting System; NHTSA, National Highway Traffic Safety Administration

Table 1 Characteristics of occupants by seating position

Characteristics	Rear seat, outboard n = 13585 (52%)	Rear seat, center n = 2337 (9%)	Driver n = 10427 (40%)
Passenger cars	9000 (66%)	1232 (53%)	6857 (66%)
Safety belt use	3950 (29%)	352 (15%)	5962 (57%)
Male	7953 (59%)	1218 (52%)	7407 (71%)
Age			
16–19	4390 (32%)	855 (37%)	2451 (24%)
20–34	4960 (37%)	874 (37%)	4334 (42%)
35–64	2759 (20%)	463 (20%)	2827 (27%)
65+	1476 (11%)	145 (6%)	815 (8%)
Air bag present	12 (0%)	3 (0%)	6427 (62%)
Rollover	5682 (42%)	1247 (54%)	4317 (41%)
Fatalities	6657 (49%)	1025 (44%)	5137 (49%)

*The sum of the percentage may not be 100% due to rounding.

model.[7 8 10] We assigned the same time to either death or censoring to all subjects, used the Breslow method to handle the tied times to death, and stratified the estimates on vehicle. This method produces the same results as conditional Poisson regression, a procedure which is not available in our software.[7 8] We assessed whether our estimates of rear safety belt use varied by vehicle type, seating position, vehicle rollover status, age (categorized as 16–64, and 65 years or older), sex, vehicle model year, and calendar year. To evaluate interaction terms in the regression models, we used the likelihood ratio test. We found that the interaction terms for sex, vehicle model year, and calendar year were not statistically significant and therefore those interaction terms were omitted from our results. All statistical analyses were conducted using SAS version 9.1.[11]

RESULTS

During the years 2000–4, 12 071 passenger vehicles of model year 1975 through 2005, with at least one rear seat passenger aged 16 years or older in the second row of seating and at least one fatality to a rear seat passenger or driver were identified. After sequentially excluding 1162 (9.6%) vehicles with missing safety belt use information, 15 (0.1%) vehicles with a first event of fire or immersion, 122 (1%) vehicles with unknown air bag presence, 2 (0.02%) vehicles with unknown occupant sex, and 34 (0.3%) vehicles with unknown occupant injury status, there remained 10 736 (89%) vehicles and 26 349 rear seat passengers and drivers for analysis. Individuals with known data were not substantially different from those excluded because of missing data with respect to age (mean of 32.5 vs 32.0 years), proportion male (63% vs 67%), proportion who were in the rear seat (60% vs 56%), and proportion who died (49% vs 52%).

In cars there were 9000 outboard rear occupants, 1232 center rear occupants, and 6857 drivers (table 1). In light trucks there were 4585 outboard rear occupants, 1105 center occupants, and 3570 drivers. In the study sample, 52% were in the outboard rear seat, 9% in the center rear, while 40% were drivers. Safety belt use was less among rear passengers: 29% for outboard rear, 15% for center rear, relative to 57% for drivers. Rear passengers were less often male (58%) compared with drivers (71%). Among rear passengers, 33% were 16–19 years old, compared with 24% of drivers. While an air bag was present for most drivers (62%), few (15) rear passengers had an air bag. The frequency of vehicle rollover was more common for center rear occupants, 54%, relative to 42% for the outboard rear seat and 41% for drivers. Approximately 67% of rear passengers riding in light trucks were in a rollover, compared with 31% of rear passengers in cars. The frequency of fatal injury was 49% for the outboard rear seat, 44% for the center rear, and 49% for drivers.

For a passenger car occupant who used a safety belt, the risk of death was less compared with a similar occupant who was unbelted (table 2): aRR 0.42 for the outboard rear seat, and 0.30 for the center. For light truck occupants the seat belt use aRR estimates were 0.25 for the outboard rear seat, and 0.34 for the center. The aRR for safety belts was closer to zero for outboard rear seat passengers in light trucks compared with cars. The aRRs for safety belt use for rear passengers in vehicles that rolled over were closer to zero compared with the estimates from vehicles that did not roll over; this was found for both passenger cars and light trucks. Older rear occupants had aRR estimates further from zero for both passenger cars and light trucks.

DISCUSSION

In this study we estimated that rear seat occupants who wear a seat belt, compared with those who do not, can reduce their risk of death by approximately 60% in a car and 70% in a light truck.

Our estimates may be biased by either inaccuracy of safety belt information or lack of complete data about belt use. Safety belt use recorded in police crash reports has been criticized because some surviving occupants might falsely report that they used a safety belt to avoid a traffic fine.[12–14] However, the intensive investigation of fatal crashes may reduce this potential for bias. Comparing police reported safety belt use with that reported by a trained investigator, Schiff and Cummings reported that the sensitivity of the police report was 91% and specificity 88% for belt use by front seat occupants in a fatal crash.[14] Cummings reported that estimates of safety belt effectiveness in fatal crashes were similar using police-reported or trained investigator-reported belt use information.[12] Furthermore, biased reporting induced by the risk of a traffic fine may be of less importance for rear occupants, as most states did not have a law requiring the use of rear safety belts during our study period.[15] Safety belt use information was

Table 2 Adjusted relative risks of safety belt use against fatalities, compared with no safety belt use, by vehicle type, vehicle rollover status and age for rear seat passengers

		Vehicles rollover status		Age	
	All vehicles	Rollover	No Rollover	16–64	65+
	aRR* (95% CI)	aRR* (95% CI)	aRR* (95% CI)	aRR* (95% CI)	aRR* (95% CI)
Passenger cars					
Rear seat, outboard	0.42 (0.38–0.46)	0.24 (0.20–0.29)	0.51 (0.45–0.57)	0.37 (0.33–0.42)	0.69 (0.55–0.87)
Rear seat, center	0.30 (0.20–0.44)	0.10 (0.05–0.18)	0.46 (0.30–0.71)	0.28 (0.18–0.42)	0.44 (0.21–0.92)
Light trucks, vans, and utility vehicles					
Rear seat, outboard	0.25 (0.21–0.29)	0.19 (0.15–0.22)	0.39 (0.32–0.48)	0.22 (0.16–0.26)	0.41 (0.32–0.54)
Rear seat, center	0.34 (0.24–0.48)	0.15 (0.09–0.25)	0.72 (0.46–1.12)	0.31 (0.21–0.45)	0.50 (0.25–1.01)

*Adjusted relative risks after adjustment for occupant's age, occupant's sex, seating position, air bag presence, and two-way interactions of seating position and safety belt use, and vehicle type and safety belt use, vehicle type and seating position, and a three-way interaction of vehicle type, seating position, and safety belt use.

missing for 11% of our study subjects and therefore our estimates may be biased if the missing data mechanism was related to other study variables. However, individuals with complete data were not very different from those with missing data regarding fatal injury, age, proportion male, and proportion who were in the rear seat.

Evans used a type of matched-cohort method to study FARS data from 1975 through 1985, and reported that safety belt use reduced the risk of death by 18% for rear outboard seat adults 16 years or older.[4] This estimate is less than our estimate of a 60% or 70% reduction. Part of this difference may reflect the use of lap belts only in the era Evans studied, compared with the common use of lap and shoulder belts in our data. All of this difference could be explained by random misclassification of safety belt use; only 3% of the dead rear passengers in Evans' study were coded as restrained and a small amount of misclassification can severely bias risk ratio estimates toward 1 when the exposure—safety belt use—is uncommon.[10 16]

Using a method similar to that of Evans,[4] Morgan analyzed FARS data during 1988 through 1997 and reported that lap-shoulder safety belts reduced fatalities by 44% (95% CI 36% to 51%) for outboard rear occupants in passenger cars, and 73% (95% CI 63% to 80%) for rear occupants of passenger vans and sport utility vehicles.[5] Our estimates of the effects of rear seat safety belts for people in light trucks were similar, but our estimate for passenger car occupants was approximately 60%. While the analysis by Morgan should control potential confounding by crash and vehicle factors, it does not control simultaneously for individual-level characteristics such as age, sex or air bag presence.

Analyzing FARS data from 1990 to 2001, using a matched-cohort regression method, Smith and Cummings estimated the aRRs for safety belt use were 0.42 for rear passengers 13–29 years, 0.42 for those 30–59 years, and 0.59 for those 60 years and older.[6] Our estimates for rear passenger car occupants were similar to these, but our aRR estimates for light trucks were closer to zero. We suspect the main reason for these differences is that 84% of the vehicles studied by Smith and Cummings were passenger cars, and therefore their estimates averaged across all vehicles should approximate our estimates for cars, but not light trucks.

Safety belts appeared to offer more benefit for rear outboard occupants of light trucks (aRR 0.25) compared with rear outboard occupants of cars (aRR 0.42). Much of this difference was explained by the propensity of light trucks to roll over more often compared with cars. As shown in table 2, the safety belt aRRs were more similar for cars and trucks when comparing vehicles that either did or did not roll over. Seat belts appeared to be most useful in rollover crashes, presumably because they prevent ejection for many passengers.

IMPLICATIONS FOR PREVENTION

In the vehicles we studied, 7682 adult rear occupants died who were not using safety belts. If our estimates of rear safety belt use are causal, approximately two thirds of these deaths could have been prevented if all rear occupants used safety belts. This would reduce crash deaths in the US by 1000 per year.

As of March 2003, 25 of 29 European countries required safety belt use in the rear seat.[17] In the US, in 2004, only 12 states and the District of Columbia had laws requiring adult rear passengers to wear safety belts.[15] There is evidence that safety belt laws increase safety belt use, although most of the evidence is based upon studies of front seat occupants.[18 19] It seems possible that either further education about the benefits of safety belt use for rear occupants or safety belt laws applied to more rear occupants might increase rear belt use and reduce crash mortality.

Key points

- Up-to-date estimates of the effectiveness of safety belts for adult rear seat passengers are provided for both passenger cars, and light trucks, vans and utility vehicles.
- The effectiveness of rear seat safety belts in reducing fatalities is estimated to be approximately 60% for rear seat positions in passenger cars and 70% in light trucks, vans and utility vehicles. Rear safety belts appear to be more effective in a vehicle rollover.
- Safety belts were more effective among rear seat passengers 16–64 years of age than those of 65 years and older.

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Authors' affiliations

M Zhu, Bureau of Injury Prevention, New York State Department of Health, Albany, New York, USA
P Cummings, School of Public Health & Community Medicine and Harborview Injury Prevention & Research Center, University of Washington, Seattle, Washington, USA
H Chu, Department of Epidemiology, The Johns Hopkins University, Baltimore, Maryland, USA
L J Cook, Intermountain Injury Control Research Center, The University of Utah, Salt Lake City, Utah, USA

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